Supercritical CO2 Extraction and Chiral Supercritical Fluid Chromatography for Ocean Worlds

Completed Technology Project (2017 - 2018)

Project Introduction

Scientific Objectives: With future in situ missions to Ocean Worlds now within reach, robust instrumentation technologies are needed for accurate analysis of biomarkers and chiral species (one of the key indicators of extant life) from complex or unknown matrix materials. Supercritical CO2, a stable inorganic solvent with ideal extraction properties (high diffusivity/permeability, low viscosity, zero surface tension), can be easily combined with chromatography to extract and separate a wide variety of organics, including chiral species, from complex sample materials without derivatization. The goal of this proposal is to extend our current capabilities in Supercritical CO2 Extraction to include Superfluid Chromatography (SCE-SFC), and to validate this instrument in a proof-of-concept study for extraction of relevant biomarkers from aqueous or mixed-aqueous/regolith samples with minimal sample preparation and minimal organic solvent waste. Methodology: Over the past decade, we have worked to develop and miniaturize an instrument for supercritical CO2 extraction of polar and nonpolar organics in our lab at JPL, and have successfully used it to extract fatty acids and amino acids from soil samples. With our technique, we also found that the extraction of ppb-level organics using pure supercritical CO2 could be accomplished without degradation of organics and without transfer of salt from the sample. This indicates that extraction with supercritical CO2 could sidestep some of the major analytic challenges from conventional techniques such as pyrolysis and conventional liquid extractions. We therefore propose to modify our current supercritical extraction system for chiral separation and detection of biomarkers to demonstrate the relevance of the SCE-SFC technique to aqueous samples of Ocean Worlds. On-line coupling of supercritical CO2 extraction with chromatography in the form of SCE-SFC was first reported in the 1980s, is faster than HPLC, and many SCE-compatible chromatography columns, detectors, and accessories have since been developed and are available for commercial purchase. With a simple incorporation of sorbent material, we will first expand the current instrument's soil-analysis capabilities to extract organics (including biomarkers and chiral molecules) from aqueous samples. Then, to allow for separation and analysis of biomarkers and chiral molecules, we will interface our current extractor to a commercially-available chromatography column and detector back-end. The end product will be a benchtop proof-of-concept instrument that will be tested with biomarkers and chiral species in aqueous samples with and without salt and without complex sample preparation. Relevance to COLDTech: The proposed instrument will enable us to detect and identify chiral molecules and astrobiologically-relevant species that may be indicative of past or present life in future missions to Ocean Worlds or other bodies, as solicited in the COLDTech call. SCE-SFC instrumentation will reduce sample preparation and waste, and will be capable of extracting and separating organics regardless of whether the sample matrix is aqueous, salty, solid, or a complex mixture of these.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Concepts for Ocean Worlds Life Detection Technology

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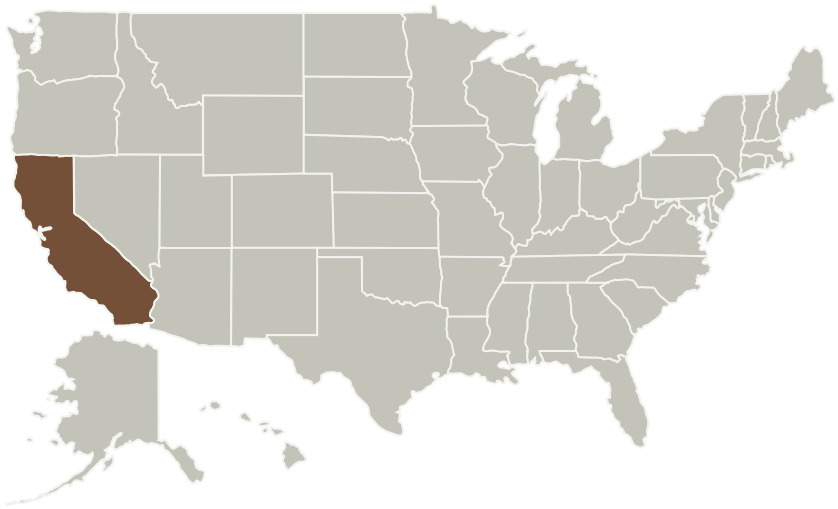
Anticipated Benefits

Our supercritical CO2 extraction and chromatography instrument extracts, concentrates, separates, and analyzes organics from saltwater, regolith, ice, or any organic or mineral matter. This green and relatively low-risk technology will solve critical sample processing and analysis problems related to in-situ exploration.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Carolyn R Mercer

Principal Investigator:

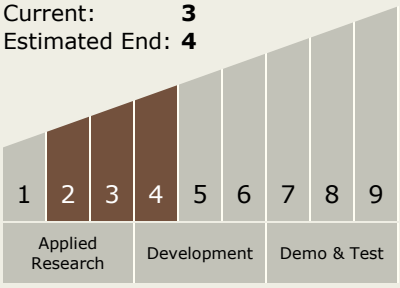
Bryana L Henderson

Co-Investigators:

Karen R Piggee
Ying Lin
Fang Zhong
Isik Kanik

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **4**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.4 Environment Sensors

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Target Destination

Others Inside the Solar System